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SCREW CONNECTION WITH SUCCESSIVELY CONNECTED BRACING REGIONS OF AN INCREASING DEGREE OF PRESTRESSING

[Schraubenverbindung mit hintereinandergeschalteten Verspannbereichen zunehmenden Vorbelastungsgrades]

Paul Kaehler

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In patent 685470 the object of exploiting the smaller increase of the cyclic load in the bracing region of a higher degree of prestressing, which increase is present in screw connections with successive bracing regions of an increasing degree of prestressing of the same screw thicknesses, is achieved by the arrangement of decreasing thread thickness in bracing regions of an increasing degree of prestressing which are successively connected in the direction of the screw axis. This arrangement does not exhaust the possible applications of the inventive idea. It cannot easily be used among others for conventional cap screws and through bolts, likewise not where there is space for tightening the tension nut only on a flange and a thread in the opposing flange for any reasons, for example due to the resulting shortening of the expansion length and bending length, is not desirable, and the like. /1[*]

This invention shows a new approach to exploiting the indicated inventive idea for opening further applications to it. As claimed in the invention the bracing regions of an increasing degree of prestressing with the assigned threads are arranged connected in succession perpendicular to the screw axis such that the bolt thread assigned to the bracing region of a low degree of prestressing is present on a sleeve-like part which surrounds the screw, preferably over a partial length, which sleeve-like part itself at least over a partial length belongs to the bracing region of a higher degree of prestressing. This sleeve-like part is compressively pretensioned at least in its partial length which belongs to the bracing region of a higher degree of prestressing.

[*] Numbers in the margin indicate pagination in the foreign text.

The invention will be further detailed using the two embodiments /2 shown in Figures 1 and 2.

The screw a of Figure 1 is provided on the ends with threads b_1 and b_2 and the pertinent nuts c_1, c_2. The sleeve d whose upper part has a thread c is stretched over the shaft. The sleeve is supported in the screw connection against one f of the parts which are to be connected. It is compressively loaded when the screw is tensioned by the nut b_1 (or b_2). If then the tension nut h which engages the bolt thread e of the sleeve is screwed against the part g to be connected, the parts f and g are pressed against one another. At the same time the loading of the screw a increases, while the compressive loading or pretensioning of the sleeve decreases. We have two successively connected bracing regions of an increasing degree of prestressing, the screw and sleeve over their entire expansion length also being assigned to the bracing region of a higher degree of prestressing.

The load distribution in this bracing region of an increasing degree of prestressing during pretensioning and under operating loads results from the known regularities in braced screw connections and can be represented most easily using the known force-elongation diagram, advantageously the representation of the load distribution in the two bracing regions being summarized in a diagram.

Diagram 3 shows this load distribution in two bracing regions.

Cz_1, $Czsp_1$ label the spring constants of the parts which have been increasingly loaded as the operating load P increases,

Ca, $Casp_1$ label the spring constants of the parts which have been decreasingly loaded as the operating load P increases,

V_1, Vsp_1 label the pretensioning forces in the two bracing regions,

Pz_1, $Pzsp_1$ label the change of the load of the Cz_1 or $Czsp_1$ parts under the operating load Pe,

Pa_1, $Pasp_1$ label the change of the load of the Ca or $Casp_1$ parts under the operating load Pe.

The addition sp indicates belonging to the bracing region of a higher degree of prestressing; in Figure 3, for comparison purposes, Cz and Pz of the singly braced conventional screw connection of the same screw dimensions are indicated.

An operating load P which occurs in the braced connection and which seeks to move the parts f and g away from one another increases the loading of the Cz_1 parts to which the screw and sleeve belong as the pretensioning V_1 decreases in the bracing region of a low degree of prestressing by Pz_1. Since this increase of loading in the downstream bracing region of a higher degree of prestressing is distributed between the sleeve which belongs to the spring constant $Casp_1$ and the screw which belongs to the spring constant $Czsp_1$ relative to these spring constants, the portion $Pzsp_1$ remains as the changing increase of loading of the screw, the portion $Pasp_1$ remains active as the changing decrease of loading of the sleeve. The portion $Pzsp_1$ at given P can be kept as small as desired by suitable choice of the spring constants with variable F, 1 and E.

Since bracing of a higher degree of prestressing of a certain screw length against an additional cross section (sleeve) increases the spring constant Cz_1 in the bracing region of a low degree of prestressing and thus Pz_1, a bracing length of a higher degree of prestressing over a partial length as short as possible is more advantageous that the same bracing over the entire length of the screw.

It increases the spring constant Cz_1 of the bracing region of a low degree of prestressing only over a partial section of the screw length, thus on this partial section enables the choice of the most favorable ratio of the spring constants Czsp and Casp of the bracing region of a higher degree of prestressing with a reduced reaction on Cz_1.

The magnitude of the allowable loading of the parts braced against one another for fixed spring constants, therefore also fixed cross sections, depends on the part with the smallest allowable cyclic stresses. Therefore in this case it is desirable for the allowable cyclic stresses of the sleeve to be at least equal to, better higher than those of the threaded part of the screw. The allowable cyclic stress of the sleeve in the versions of Figures 1 and 2 is dependent mainly on the size of the tension peak in the thread root. This tension peak is reduced for a given thread shape

A) by reduced bending and shear stress of the thread crests,

B) by more uniform distribution of the stress over the bearing core cross section,

C) by suitable material.

For the sleeve, in contrast to the known means (nut with round spigot, elastic thread, unequal thread pitch of nut and bolt, surface pressures, nitriding of the thread, hollowing out of the screw, and others) there is simultaneous use of the possibilities given under A to C. The compressively braced thread part of the sleeve yields the following /3

A a) more uniform distribution of the loading on the threads of the tension nut-sleeve coupling than in the conventional bearing

nut/screw bolt coupling as a result of the compressive prestress (or absence of tensile loading) of the sleeve.

b) a larger outside diameter of the sleeve thread than for the screw thread, accordingly increased bearing capacity for the same bending and shear stress of the crests on the thread root,

B a) relief of the most highly stressed fibers as a result of compressive pretensioning in the threaded part of the sleeve,

b) more uniform distribution of the load over the core cross section by drilling of the sleeve,

c) an increase of the service life by the force component of the flank loading of the thread, which component compresses radially to the inside and is present at the same time with the compressive pretensioning,

C) possibility of choosing a suitable material for the thread part of the sleeve independently of the material of the screw bolt.

The allowable rated stress of the thread cross section of the sleeve, assigned to the bracing region of a higher degree of prestressing, according to the aforementioned can become greater than the allowable rated stress of the continuously loaded thread cross section of the screw bolt. Thus in Figure 1 it is not always necessary to keep the sleeve cross section larger than the cross section of the thread of the screw only for reasons of cyclic stress in the thread root, the more so that the amount of space required decreases with the decreasing core cross section of the sleeve. By reducing the cross section of the smooth sleeve shaft relative to the core cross section of the sleeve thread the stress conditions can still be improved.

The highest total load (resting + cyclic) is the same in the sleeve and the screw, when the pretensioning in the two bracing regions becomes zero at the same time, as is assumed in Diagram 3 for the sake of clarity. In this connection, the compressively loaded sleeve part is superior to the continuously loaded thread part of the screw with respect to total load bearing capacity at the same cross sections. For practical reasons the pretensioning in the bracing region of a higher degree of prestressing will be so high that complete relief in this bracing region occurs somewhat later than in the bracing region of a low degree of prestressing. This measure results simply in a small increase of the total loading of the screw as it is fully relieved.

Figure 2 shows a version in which only part of the expansion length of the screw lies in the bracing region of a higher degree of prestressing in order to be able to reduce the portion of the cyclic operating load which must be accommodated by the thread part of the screw more radically than in the version of Figure 1 and more radically in the screw shaft. In Figure 2 the sleeve d outside bears the bolt thread for the tension nut h, inside, the nut thread for the screw thread b. To produce bracing between the screw and sleeve the sleeve is prescrewed using the slot j up to its shaft part k striking the collar 1 of the screw and as far as the desired pretensioning. Then the flanges f and g are pressed together by the tension nuts h. In doing so the screw loading increases as the pretensioning is reduced between the flanges f and g and the parts d and l. The action is accordingly described in fundamentally the same manner as above for the version of Figure 1.

But as a result of the assignment of only one part of the screw length to the bracing region of a higher degree of prestressing, the portion Pz of the operating load which acts on the bracing region of a higher degree of prestressing as a cyclic load becomes only slightly larger than for the normal screw connection, while on the other hand it is distributed among the indicated cross sections roughly in a ratio of the cross sections of the screw core and sleeve core (for the same E and same length) or more accurately in a ratio of the spring constants of the lengths of the screws and sleeves, which lengths are braced against one another.

The braced sleeve length need not be kept excessively short since the decrease of Pz at the length of the screw which is braced against the sleeve, which length is smaller relative to the total expansion length, makes itself less noticeable; moreover very short sleeve lengths under certain circumstance lead to other disadvantages. The adverse effect of an overly short thread groove above the collar l is known.

A force-elongation diagram for a screw connection as shown in Figure 2 is shown in Diagram 4. Compared to Diagram 3, the important difference lies in that as a result of the bracing region of a higher degree of prestressing which extends only over a partial length of the screw, therefore a shorter spring length, the spring constants Czsp and Casp of the bracing region of a higher degree of prestressing are inherently greater than the same spring constants in Diagram 3, but as a result of the shorter length of their influence on the spring /4
constant in the bracing region of a lower degree of prestressing, this spring constant is much smaller than Cz_1 in Diagram 3, so that also Pz_2

$< Pz_1$. This shows the greater efficiency of the bracing region of a higher degree of prestressing over a partial length of the screw, and its greater independence in the choice of the sleeve cross section to achieve the desired load distribution, and the bearing capacity of the bolt thread under a cyclic load can determine the allowable load level. For this reason the conditions in Figure 2 are still more favorable than as already described for Figure 1.

If in Figure 1 the nut c_1 with the thread part e of the sleeve is combined into a sleeve with inside and outside thread, it can be advantageous, especially for longer sleeves, to make the unthreaded sleeve part as a separate part. This enables a sleeve of uniform height $h = c_1 + e$ to be fabricated for different required sleeve lengths. In Figure 2 the shaft part k would be accordingly separated from d. A collar-like reinforcement of the separating surface yields a greater support surface when the sleeve nut is prescrewed. The outside and inside thread can be arranged as in Figure 2 axially at the same height, or when axial space is present, can be displaced up or down against one another, a displacement up under certain circumstances requiring thicker core cross sections for the outside thread of the sleeve.

In the version of Figure 1 the nut c_1 or c_2 can be replaced by a screw head or the nut c_2 by a thread in the flange f.

One special advantage of the invention arises when the pretensioning in the bracing region of a low degree of prestressing is lost by some circumstance, for example by blowout of a washer. Then a singly braced screw connection must accommodate the entire changing operating load, while for double bracing, bracing of a higher degree of

prestressing continues, the operating load is distributed between the screw and sleeve up to complete relief, and the screw is unloaded. This safeguard alone yields a sufficient advantage for use of a screw braced over the entire length as claimed in the invention in a special case. Here the indicated action is especially ensured when continuous deformation of the thread crests under an overload occurs first in the thread of greater diameter. In this sense, higher stressing of the thread crests of the larger thread diameter is not a disadvantage, but rather an advantage.

Claims

1. Screw connection with successively connected bracing regions of an increasing degree of prestressing and decreasing thread thicknesses assigned to them according to patent 685470, characterized in that the bracing regions of an increasing degree of prestressing with the assigned threads are arranged connected in succession perpendicular to the screw axis such that the bolt thread assigned to the bracing region of a low degree of prestressing is present on a sleeve-like part which surrounds the screw, preferably over a partial length, and thus sleeve-like part at least over a partial length belongs compressively pretensioned to the bracing region of a higher degree of prestressing.

2. Screw connection, especially as claimed in Claim 1, characterized in that the endangered core cross section of the outside thread of the sleeve-like part is assigned to the bracing region of a higher degree of prestressing under compressive prestress and is smaller than the continuously loaded core cross section of the bolt thread of the screw belonging likewise to the bracing region of a higher degree of prestressing.

3. Screw connection as claimed in Claims 1 and 2, characterized in that the sleeve-like part outside bears the bolt thread of the bracing region of a low degree of prestressing, inside, the nut thread of the bracing region of a higher degree of prestressing.

4. Screw connection as claimed in Claims 1 to 3, characterized in that the sleeve is axially subdivided and one of these parts is unthreaded.

1 page of drawings attached

Fig. 1

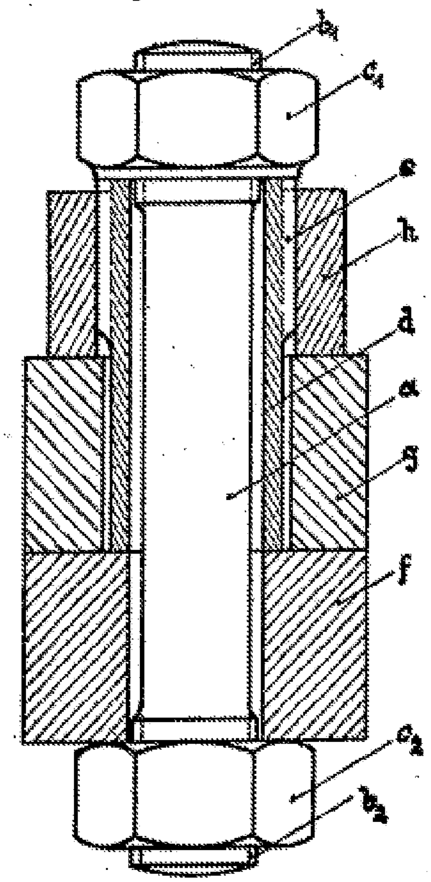

Fig. 2

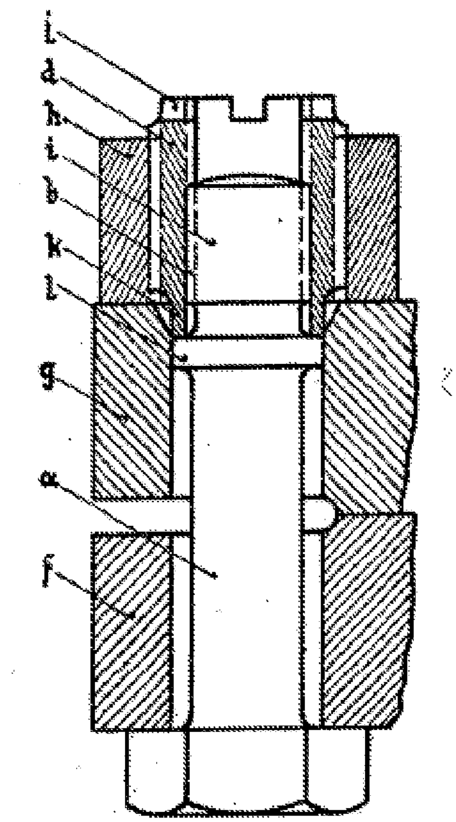

Fig. 3

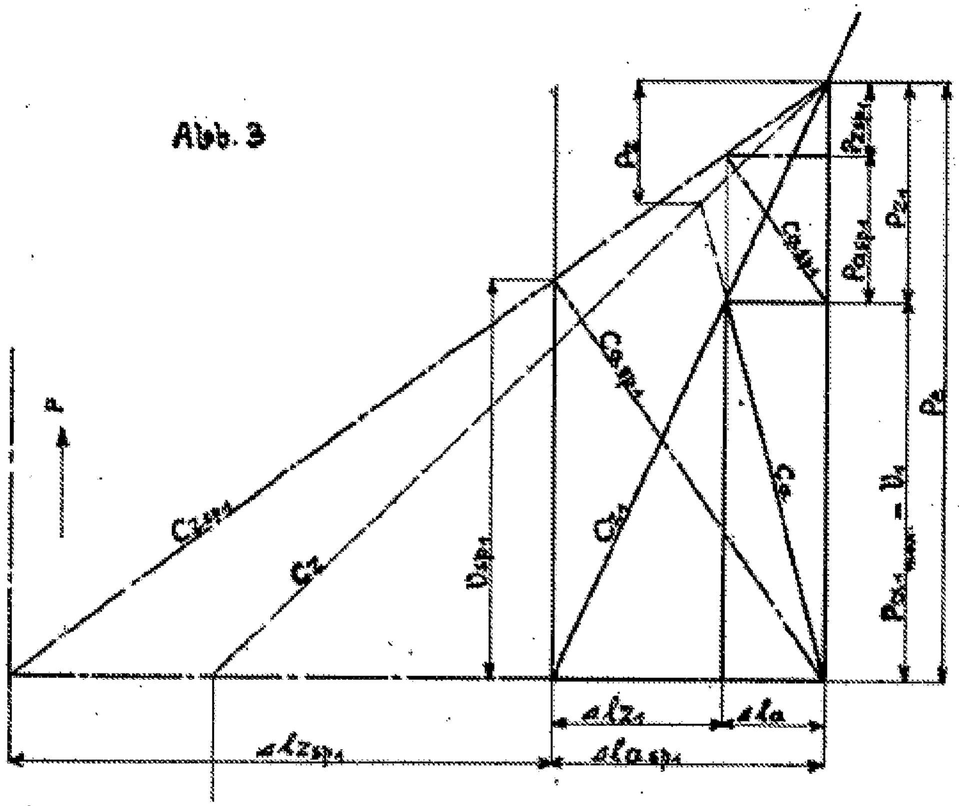

Fig. 4